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EFFICACY OF SOLAR HEAT IN THE CONTROL OF BACTERIAL SOFT ROT OF POTATO TUBERS CAUSED BY *ERWINIA CAROTOVORA* SSP. *CAROTOVORA*

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Abstract: The efficacy of solar heat in the control of bacterial soft rot of potato tubers was investigated in Maiduguri, semi-arid region of Northeastern Nigeria. Artificially contaminated tubers were exposed to solar heat for duration of 0, 30, 60, 120 and 180 minutes. The results showed that exposures for 120 and 180 minutes gave the highest control of the disease, although during the hot dry season (mean temperature at exposure was 54.6°C) exposure even for 30 minutes gave satisfactory control of the disease. Solar heat can therefore be used to control of bacterial soft rot of potato tubers.

Key words: potato tuber, soft rot, solar heat, control

INTRODUCTION

Potato tuber soft rot is a major disease in potato production world-wide. The effect of the disease is however more pronounced in the developing countries where appropriate storage facilities are lacking. In Nigeria, though the disease constitutes a major problem in storage, not much has been done regarding control of the disease. Cold storage which is used in the developed countries is not feasible in Nigeria due to the erratic electricity supply. No chemical has been found to provide satisfactory control of the disease even in the developed world (Harris 1979). Air drying of tubers before storage has long been recommended by some authors (Bartz and Kelman 1985b; Hide and Broorer 1991). In Nigeria potato tubers are packaged in sacks immediately after harvest for transportation to different parts of the country. This has led to increased losses of tubers to soft rot in transit and storage as the tubers were eventually stored in the sacks stalked in unventilated zinc stores at the market sites.

Maiduguri, the study area and where a lot of potato tubers are transported to, lies in the semi arid region which is characterized by abundant sunshine almost throughout the year. The region has three distinct seasons. The "Harmattan" period between November and February with day air temperature range of 27–37°C. It is a period characterized by dusty moderately low temperature north-easterly winds blowing from the Sahara across the desert to Northern part of Nigeria. The hot dry period between March and May with day air temperature range of 39–50°C and the rainy season with day air temperature ranges of 38–45°C (Anonymus 2006). The abundant sunshine in this region has been effectively utilized in the control of storage pests. Research in this region has shown that exposure of cowpea and groundnut seeds infested by weevils to solar heat for 2–3 h gave effective control of the weevils (Lale and Ajayi 2001; Lale and Maina 2002; Maina and Lale 2004). However, unlike with insects, the effect of solar heat in controlling storage pathogens has not been given much attention.

The lack of appropriate potato storage facilities in the study area, coupled with the accompanying high losses of tubers in storage necessitates the search for cheaper and effective method of controlling the disease. It is in this regard that the effect of solar heat on the control of the disease was investigated. This paper reports the efficacy of solar heat in controlling bacterial soft rot of potato tubers caused by *Erwinia carotovora* ssp. *carotovora*.

MATERIALS AND METHODS

The experiments were conducted in the Plant Pathology Laboratory of Department of Crop Protection, University of Maiduguri, Nigeria, in January ("Harmattan" period), April (hot dry period) and August (rainy season) of 2006. These months represent the peak of the three seasons in the study area.

Potato tuber source

Farmers from Jos supplied the fresh mature tubers of potato variety Nicola used in this study. The potato tubers were obtained in December, 2005. Apparently healthy and uniformly sized tubers (about 48 000 tubers per experimental period) were selected for the experiments. The selected tubers were washed under running tap water and stored in the laboratory before the onset of the experiments.

Inoculum preparation

The *Erwinia carotovora* ssp. *carotovora* (Ecc) used in all the experiments was isolated from potato tubers showing soft rot symptoms using the semi-selective medium for isolation of Ecc as described by Bdliya and Langerfeld (2005a). Only pink or red colonies in deep cavities were subcultured into pure cultures and used as inoculum for inoculating the tubers. The bacteria were preserved on nutrient agar (NA) slants at 4°C till required. Prior to inoculation of tubers, the bacteria were grown on NA plates for 48 h at 27±2°C. The plate cultures were suspended in sterile distilled water and the bacterial concentration adjusted to 10^9cells/ml by measuring the optical density (OD) at $\lambda = 650$ nm using spectrophotometer (Lomb and Bausch USA).

Tuber inoculation

Prior to inoculation, the tubers were surface sterilized in 10% sodium hypochlorite solution for three minutes followed by rinsing in five changes of sterile tap water.

Tubers were allowed to dry at room temperature (about 30±2°C). The tubers were artificially inoculated by submerging in the bacterial suspension for ten minutes. After inoculation, the tubers were immediately exposed to solar heat.

Exposure to solar heat

To have representative effect of the solar heat in the test periods (January, April and August), four experiments on weekly basis were set out for each of the three months. Also to get full exposure to solar heat, the inoculated tubers were spread out on concrete platform in an open area outside the laboratory. Prior to the onset of the experiments, the platform was washed with 10% sodium hypochlorite solution and rinsed with sterile tap water and allowed to dry. The exposure of tubers to solar heat was all done between 12.00 noon and 15.00 pm local time when the sun was at its hottest peak. Immediately after tuber inoculation with the bacteria, the tubers were spread out on the surface sterilized platform. The actual solar heat reaching the tuber surfaces was measured by placing thermometer on the surface of the spread tubers while the relative humidity at the exposure time was measured using a whirling thermohydrograph. For uniformity, all the tubers for an experiment were spread out on the platform at the same time and four replicate samples of fifty tubers taken at the end of each exposure time of 30, 60, 90, 120 and 180 minutes and brought into the laboratory for incubation. The temperature at the beginning of the experiment and end of each exposure time were recorded and the average for the experimental period computed. The relative humidity was also recorded and computed in the same manner. The mean for the four experiments in the month were computed to give the mean solar heat for the period of experimentation (season). The controls for each experiment consisted of four replicates of fifty tubers placed in incubators in the laboratory.

Experimental set up

After the inoculated tubers were exposed to solar heat as described above, fifty tuber samples replicated four times were taken at the end of each exposure time and placed in surface sterilized plastic containers (about 40 x 40 x 10 cm) with lid and arranged on shelves in an incubator. Moist tissue paper was placed at the bottom of each container to maintain high humidity within the container. Containers containing the control tubers were arranged side by side with the exposed tubers in a completely randomized design. The tubers were then incubated for three days at 27±2°C. Evaluation was based on the incidence and severity of tuber soft rot. The tuber soft rot severity was assessed on a scale of 0–5 as described by Bdliya and Langerfeld (2005b)

where:

0 = no symptom of rot
1 = 1–15% of tuber rotten
2 = 16–30% of tuber rotten
3 = 31–45% of tuber rotten
4 = 46–60% of tuber rotten
5 ≥ 61% of tuber rotten

The severity was then computed using the formula

$$S = \frac{\sum n}{N \times 5} \times 100$$

where: S = severity of tuber rot (%);
$\sum$n = summation of individual ratings;
N = total number of potato tubers assessed and
5 = highest score on the severity scale.

Data analysis

Data obtained were subjected to analysis of variance and the mean compared either using least significant difference (LSD) or plotting standard error of means at 5% level of probability as described by Gomez and Gomez (1984).

RESULTS

The actual mean temperature measured on tuber surfaces at the time of exposure to solar heat in January was 36.2°C. In April the actual mean temperature was 54.6°C while in August it was 45.3°C. The corresponding relative humidity was 18%, 15% and 72% for January, April and August, respectively. The effect of exposure to solar heat on the incidence and severity of tuber soft rot during the three seasons is shown in Figures 1, 2 and 3. During the Harmattan period (January) exposure of the inoculated tubers for a prolonged period of 120 and 180 minutes gave significantly lower soft rot incidence and severity than the control (0 minutes). Exposures for 30 and 60 minutes gave moderate control of the disease, though only the disease severities were significantly lower than the control (Fig. 1).

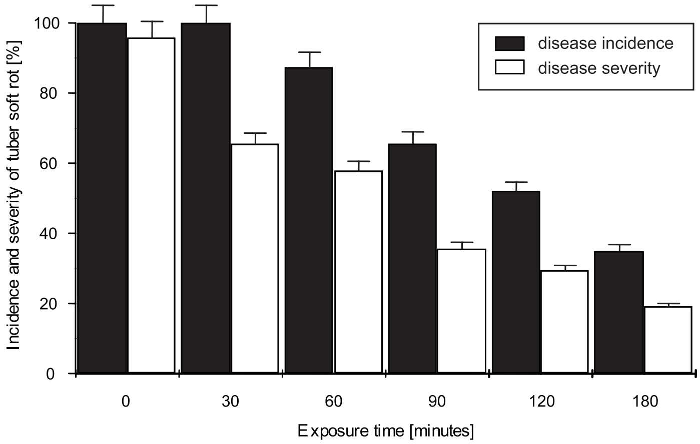

Fig. 1. Effect of solar heat on the incidence and severity of potato tuber soft rot during the Harmattan (January). Mean temperature at exposure time was 36.2°C. Mean relative humidity was 18%. Bars indicate standard error of means at 5% probability level

In the hot dry season (April), even exposures for 30 minutes gave significantly lower disease incidence and severity than the control. Exposures for 30 and 60 minutes did not differ significantly. Exposure for 180 minutes gave the lowest disease incidence and severity (Fig. 2). The effect of solar heat on the incidence and severity of tuber soft rot during the rainy season (August) showed that tuber exposure for 60 minutes and above gave significantly lower incidence and severity of tuber soft rot than the control. Exposures for 180 minutes also gave the lowest disease incidence and severity. There was no significant difference between exposures for 30 minutes and the control (Fig. 3). Generally, the effect of solar heat in controlling tuber soft rot was higher during the hot dry season (April) than during the Harmattan (January) and rainy seasons (August) and also at longer exposure periods.

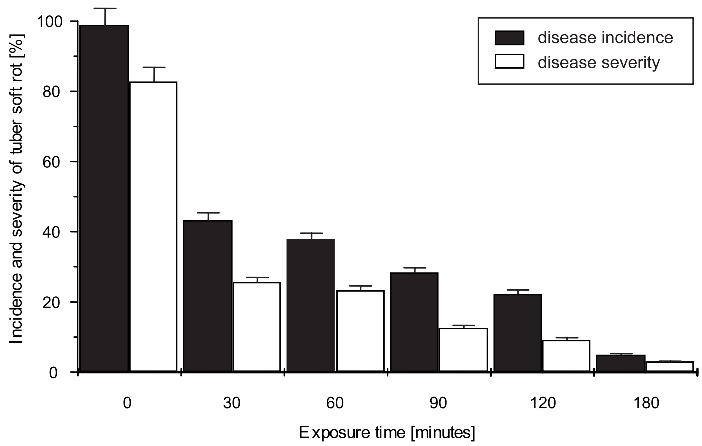

Fig. 2. Effect of solar heat on the incidence and severity of potato tuber soft rot during the hot dry season (April). Mean temperature at exposure time was 54.6°C. Mean relative humidity was 15%. Bars indicate standard error of means at 5% probability level

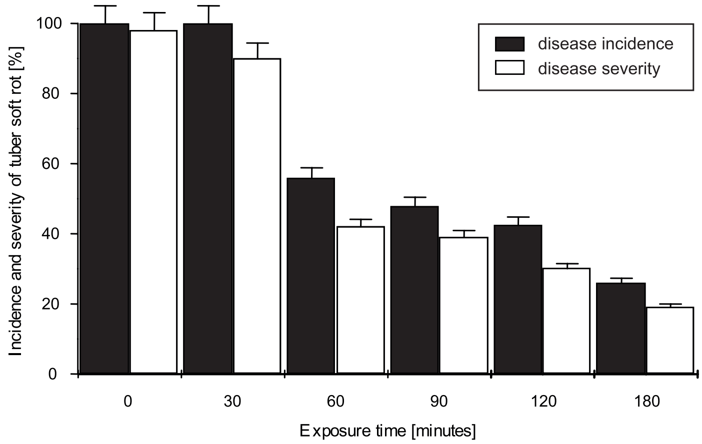

Fig. 3. Effect of solar heat on the incidence and severity of potato tuber soft rot during the rainy season (August). Mean temperature at exposure time was 45.3°C. Mean relative humidity was 72%. Bars indicate standard error of means at 5% probability level

DISCUSSION

The effect of exposing tubers to air drying as a means of reducing potato tuber diseases in storage has long been reported (Adams and Griffith 1978; Hide and Boorer 1991). The result of our study confirmed those earlier reports in the sense that exposing the tubers to air drying reduced the incidence and severity of tuber soft rot. However, from our results, it was clear that the efficacy of exposure to air drying in controlling tuber soft rot depends largely on the duration and intensity of solar heat during the period of exposure. This was evident in the exposure of the inoculated tubers to solar heat during the hot dry season (April) which gave significantly higher control of the disease compared to the Harmattan (January) and the rainy (August) seasons. Though the incidence and severity of the disease decreased with increased exposure time in January and August, the reduction was not as marked as during the hot dry season (April) having higher solar heat intensity. During the Harmattan, though the air was dry, the temperature was moderate (36.2°C) and this might not have exerted enough heat to kill the bacteria on the tuber surface. However, since the air was very dry and windy the surface of tubers at longer exposures might have been much drier than at the lower exposure times. Thus the higher incidence and severity of the disease recorded at 30 minutes compared to that of 120 and 180 minutes. During the rainy season, though the mean temperature during the experiment was 45.3°C, the atmosphere was humid and thus the absolute drying out of the tuber surfaces might have taken longer time, hence the higher incidence and severity of the disease at the lower exposure periods. Hide and Boorer (1991) reported that exposure of contaminated tubers to air drying for extended period of 2 weeks at 15°C reduced tuber diseases than at lower temperatures and reduced exposure time. In our study also, longer exposures at lower temperatures were found to be more effective in reducing tuber soft rot compared to the shorter exposure times. In April which was the hottest period of the experiment, the mean temperature of 54.6°C recorded during the experiment might have been hot enough to kill or inactivate the bacteria on the surface of the tubers giving rise to the low incidence and severity of tuber soft rot recorded. The effect of high temperature on the survival soft rot erwinias on potato tubers has long been reported by other authors (Knowles et al. 1982; Perombelon 1990). Research has shown that the thermal death point of soft rot erwinias *in vitro* was at 50–52°C under naturally contaminated tubers subjected to different temperature-time treatments. Contamination was found to be lowered to barely detectable levels at 53°C for 7 min., 55°C for 5 min., and 59°C for 3 min. (Perombelon 1990). In our study the high temperature recorded in April might have been high enough to kill the bacteria at all the exposure times and hence the low incidence and severity of the disease recorded during the period. The low incidence and severity of the disease recorded during the hot season might have originated from the bacteria deeply sealed in the lenticels which the solar heat could not reach.

On the other hand, exposure of tubers to air has been found to facilitate curing which toughen the skin against injury, promote wound healing and prevent entry of microorganisms, the long exposure periods might have also improved tuber curing in addition to the direct effect of solar heat on the microorganisms. The significance of curing potato tubers before storage in reducing the development of tuber diseases has been reported by other authors (Knowles et al. 1982).

This study has demonstrated that exposure of contaminated potato tubers to solar heat before storage can reduce the level of soft rot development in storage. However, the efficacy of the method depends on the duration and the intensity of solar heat at the time of tuber exposure. In the study area (Maiduguri) where the intensity of solar heat varies with the season of the year, longer exposures might be necessary during the Harmattan and the rainy season while shorter exposure period might be adequate to give the desired control during the hot dry season. This method might be readily adopted by farmers as it is easier and cost them nothing.

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POLISH SUMMARY

SKUTECZNOŚĆ NASŁONECZNIANIA BULW ZIEMNIAKA W ZWALCZANIU ICH MOKREJ ZGNILIZNY POWODOWANEJ PRZEZ *ERWINIA CAROTOVORA* SSP. *CAROTOVORA*

Przedmiotem pracy było badanie skuteczności nasłoneczniania bulw ziemniaka w zwalczaniu ich mokrej zgnilizny. Studia przeprowadzono w Maiduguri, leżącym w półsuchym regionie północno-wschodniej Nigerii. Sztucznie zakażone bulwy poddawano nasłonecznianiu przez okres 0, 30, 120 i 180 minut. Wyniki dowodzą, że 120 i 180 minutowa ekspozycja powodowała największe ograniczenie choroby, chociaż podczas pory suchej i gorącej (średnia temperatura podczas ekspozycji wynosiła 54.6°C) nawet 30 minutowa ekspozycja dawała satysfakcjonujące wyniki. Nasłonecznianie więc może być stosowane w zwalczaniu bakteryjnej mokrej zgnilizny bulw ziemniaka.